PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1929

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PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1929

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REPORT OF THE DIRECTOR

By D. W. May

The work of the station during the year was devoted primarily to problems of research. Tests of plants and animals and of methods of conservation and production naturally followed as correlatives.

The seasons generally were favorable to plant growth. Buildings that were either badly damaged or destroyed by the hurricane of September 13, 1928, were reconstructed. These buildings are stronger and more permanent in character than were the former buildings. The station lands, buildings, and equipment are in much better condition than they have ever been.

There were no changes in personnel during the year. The position of entomologist remains unfilled.

The appropriations made by Congress for the year were $56,460 for maintenance and, from the deficiency act, $9,500 for the purpose of repairing damages caused by the hurricane in September. The latter sum was supplemented by an appropriation of $1,300 transferred from the Office of Experiment Stations. The sum allotted for the operation of the station was the same as in the previous year.

The amount allotted for research was economically and judiciously expended. An increased appropriation could be employed efficiently in the work of the station.

BUILDINGS AND IMPROVEMENTS

The station suffered severely from the hurricane in September. The first work undertaken was the replacement of roofs, and the next was the rebuilding of laborers' cottages, which were in some cases totally destroyed. The large greenhouse with a steel frame 22 by 59 feet was re-covered with glass. The wooden warehouse, 39 by 50 feet, which was entirely destroyed, was rebuilt of concrete with walls 8 inches thick. The wooden garage, 23 by 42 feet, was a total loss.

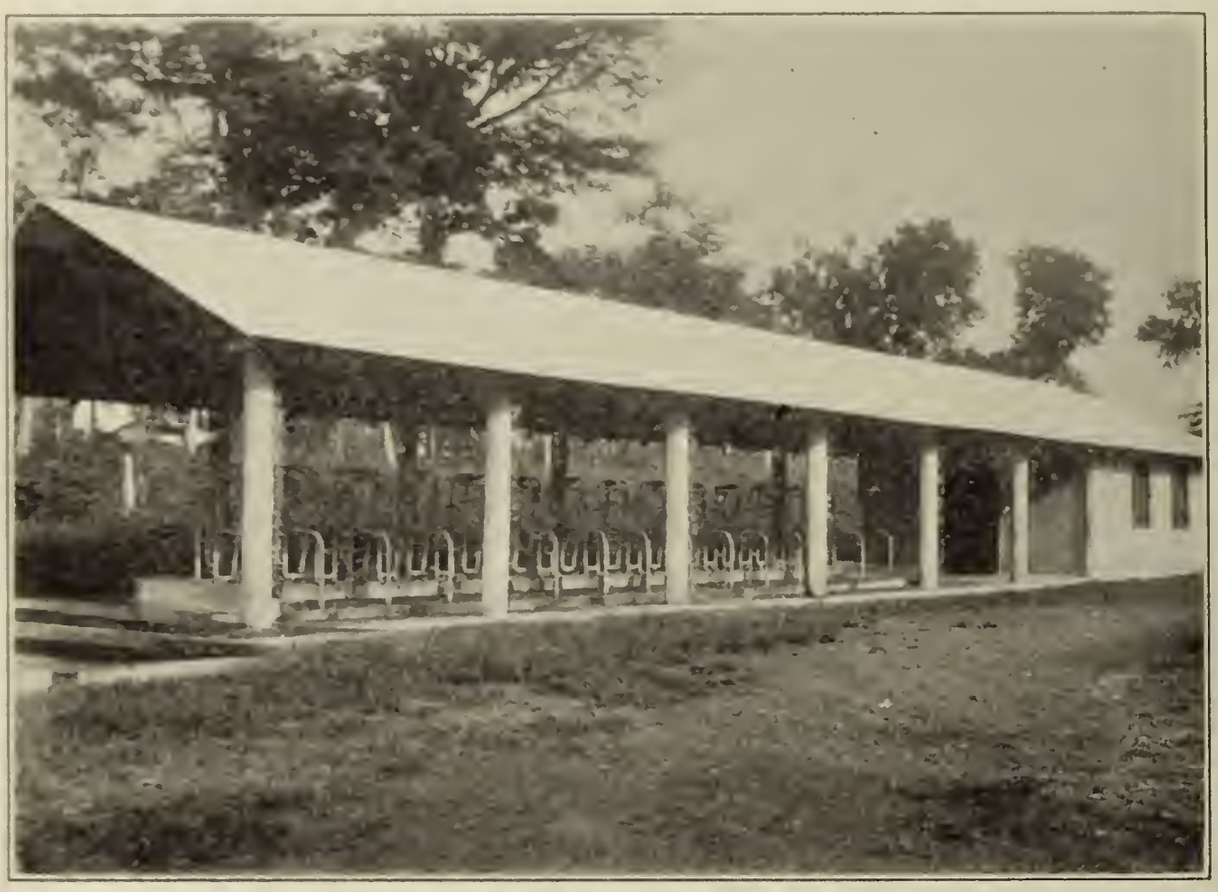

FIGURE 1.—Milking shed and feed room

It was rebuilt of concrete with walls 8 inches thick. The milking shed, 18 by 64 feet, also destroyed, was rebuilt with a feed room, 18 by 22 feet, at one end. (Fig. 1.) New steel stalls were set in the concrete.

The wood used in the roofs of these buildings is pine. The timbers were treated with mercuric chloride and creosote as a precautionary measure against insect pests which are very destructive to softwoods in the Tropics. The colors applied were creosote stains.

The building 50 by 60 feet, in use as the plantation residence when the property was purchased by the Government and more recently used for breeding small animals, was blown down. The location of this building was not in harmony with that of the other station buildings and was therefore not rebuilt upon. Instead, two wings, 22 by 45 feet, two stories high, were added to the main building and equipped with light, water, and gas. The doors and windows are of redwood and were made at the station. The walls are 10 inches thick. (Fig. 2.)

The walls of the concrete buildings were made thicker and stronger than would seem to be necessary in the hope that they will withstand the force of hurricanes occurring in the future.

BUILDING MATERIALS

Lumber, cement, and iron, the chief building materials, are imported into Porto Rico, and the demand for them is great and increasing. Because of their expense they should be used as little as possible, such materials as lime, clay, sand, and gravel, which can be obtained locally, being substituted whenever practicable.

The pisé de terre, or rammed earth, house built two years ago has not stood up well. Large cracks have occurred in the walls and in places the surface has scaled off. The humidity of the atmosphere

FIGURE 2.—Office and laboratory building

varies widely in Porto Rico and the rainfall is about 75 inches per year. The daily drying and dampening of the air tends to disintegrate the clay and the driving rains make it difficult to protect the outer surface of the wall.

Continued good results are had with soft limestone or coral deposit, locally known as "tosca," when hardened with cement. A mixture of only 1 part cement with 20 parts tosca will set quickly and firmly. The surface of the combination may be hardened by brushing with cement in water or with water glass. A mixture of 1 part cement, 10 parts tosca, and 10 parts sand did not make as strong a construction as did the proportion of 1 to 20. The addition of small amounts of gypsum to the cement-lime mixtures increased their strength. The use of the fiber of the coconut husk as a binder reduced the cohesive properties of the mixture. The use of reinforcing irons in the mass was of no value because the mixture would not adhere strongly to them.

CATTLE

The local cattle show steady improvement in quality and quantity of milk. Improvement has been brought about by crossing the native stock with introduced breeds. Crossbreeding is resulting in early maturity and increased yields of milk and butterfat. Keeping pace with crossbreeding results are the construction and better equipment of dairies where sanitation is thoroughly practiced.

The local climate does not inhibit the growth and development of a high-grade breed of cattle, and excellent fodders and feeds can be grown in large amounts economically. Parasites probably are the chief deterrent factors. Of the external parasites affecting cattle here the tick is the worst, and the internal parasites are many and of varied kinds. The work of the station in combating the parasites of livestock is noted in detail on page 26.

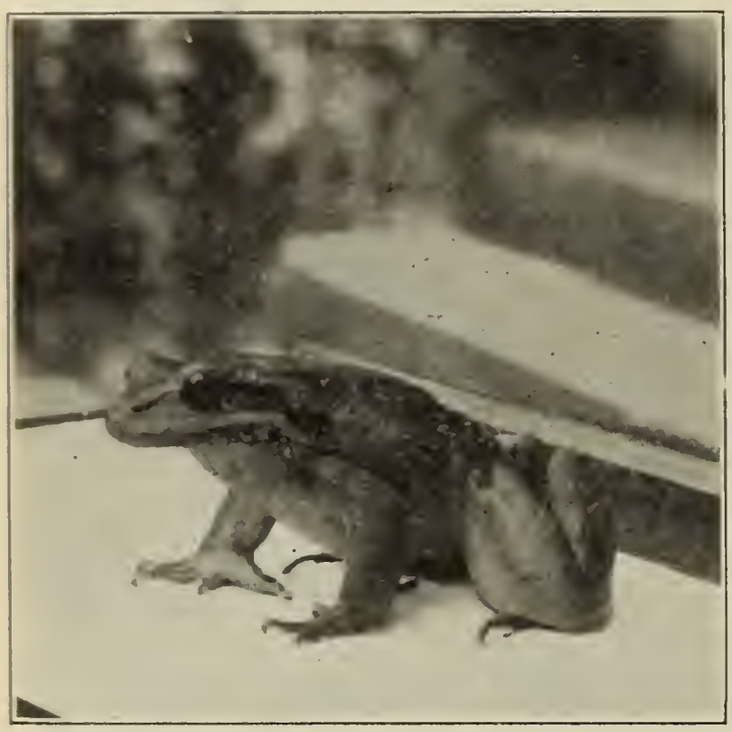

FIGURE 3.—Dominican frog (*Leptodactylus pentadactylus*)

SURINAM AND DOMINICAN TOADS

The giant toads (*Bufo marinus*) which were introduced into the island from Barbados five years ago have been sent to different parts of Porto Rico in lots varying from 12 to 2,000. They have become well established and apparently are effective in reducing the depredations of some of the worst insect pests, especially the night feeders and the burrowing kinds. The Surinam toad has not been found to be adapted for use as food.

During the year a dozen frogs (*Leptodactylus pentadactylus*) were introduced from Dominica, where they are known as "mountain chickens." They have been released near Mayaguez in the hope that they will serve as destroyers of insects and also prove valuable as a food product. (Fig. 3.)

LIME IN ANIMAL PRODUCTION

Lime is essential in the formation of bone, and its presence in the blood and tissues indicates that it is also needed structurally elsewhere in the body. The importance of lime as a constructive element in building body tissues, especially bone, and in promoting nutritive processes, notably in the case of wasting diseases, has long been appreciated in medicine. Plants may sometimes adapt themselves to mineral deficiencies. For example, willows growing in wet lands have a much lower mineral content than those growing on dry lands. Animals doubtless have the same adaptability to a certain extent. The animal organism is known to be protected from certain ailments by the feeding of proper mineral supplements. The relation between growth and proper feeding is so obvious in quick-maturing animals like pigs that it is now a common practice to feed them mineral

matter. Osteoporosis, a disease of horses, is caused by a lack of lime in the feed or the drinking water. In this disease the bones of the horse, especially those of the head, become porous and soft. The remedy is the feeding of lime salts in an assimilable form. In Porto Rico osteoporosis occurs where the soil is deficient in lime and becomes more pronounced during the rainy season when the grass is most deficient in mineral matter. Horses reared in the limestone regions of the island do not suffer from osteoporosis and the affected animals in the unfavorable areas can be cured if they are transferred to the limestone regions. Aggravated cases at the station have been cured. Many of the clay soils in the central region of Porto Rico are deficient in lime, it sometimes falling to below 2 per cent. In this region young stock does not thrive as in the limestone regions along the north and south coasts. At the station where the soil is clay comparatively few cattle are brought to maturity. They are secured when grown from the region south and east of Cabo Rojo. To overcome the lime deficiency in feeding rations at the station mineral matter is placed in the water tanks, or with the salt, or in the feed.

A series of experiments with pigs was carried out in order to learn more definitely the influence of lime on the growth of animals and the economic gains with certain rations. The use of lime in the drinking water, using a saturated solution, gave no consistent results. Apparently not enough lime was held in the amount of water drunk to make an appreciable difference between the growth of the pigs in the five lots tested, or in the amount of feed they consumed per pound of gain. In experiments with pigs receiving 8 to 33 grams of bone meal per animal per day in the ration favorable results were obtained both in the rate of gain in weight and the percentage increase in growth for the amount of feed fed. In experiments with calcium carbonate in the feed yet more favorable results were obtained. The pigs were given amounts varying from 14 to 56 grams each per day in the ration. The daily gain in body weight was favorably affected by the addition of lime in the ration, whereas the increases were obtained with a lessened consumption of feed. The feeding of lime in some form in the clay districts of Porto Rico is highly advisable. Sea salt is available here at low cost and should be kept accessible to animals at all times. It should be mixed in equal parts with lime or bone meal. In this way it is possible at least partially to overcome the lime deficiency in most districts.

LEGUMES

Legumes may be important factors in a locality's prosperity. They may serve three useful purposes: (1) As food, (2) as an improved feed for livestock, and (3) to improve the soil by storing nitrogen from the air. Several of the legumes indigenous to Porto Rico are effective in improving the soil. The station is continually seeking others that will not only improve the soil but also aid in increasing the local food supply.

One of the two most important items in the local dietary is the bean. It grows in all parts of the island and during nearly all seasons. For some years the station has been growing garden peas, which are apparently a new crop in Porto Rico because the seed have to be inoculated before the roots will produce the nodules that store nitrogen from the air. The growing of this crop should be extended in the

island. The vegetable is delicious, the vines make an excellent forage for livestock, and the roots improve the fertility of the fields to an unusual degree. With a long growing season such as prevails in Porto Rico, the tall-growing varieties should be planted. The wrinkled kinds are the sweeter. Before the crop is planted for the

FIGURE 4.—Velvetbeans growing on banana plants

first time the seed should be inoculated with material obtained from the station. Seed from the first crop should be saved for further plantings, which should be as continuous as possible.

The velvetbean, another recently introduced legume, should be more extensively planted than it is, as an ornamental plant, a green manure, and a forage produce. It grows rankly, smothers out other

undesirable plants such as nut grass, mellows and fertilizes the soil, and provides an excellent feed, both vine and seed, for livestock. (Figs. 4 and 5.)

FIGURE 5.—Velvetbeans growing over sugarcane

Rapid-growing legumes like peas and beans are well able to hold their own with other quick-growing plants competing with them in the Tropics.

SOYBEANS

Porto Rico needs another nitrogenous food crop—a legume that can be depended upon to supply a large variety of food products and at the same time be free from attack by fungus diseases and insect pests. The soybean in a measure meets these requirements, but as yet is not grown extensively on the island. The station has been experimenting with the soybean for some years and finds it most promising. It not only materially improves the soil but also furnishes forage and grain, the latter being especially needed for livestock. The soybean will supply the much needed and now largely imported nutrients, protein and oil, in the local dietary when the people acquire a taste for the food products made from it. Two types of soybeans are grown locally. One is the round bean, used as food and for oil extraction, the other is a flattened bean of smaller size but with larger vine growth, used for forage for livestock. In tests of the Mammoth Yellow of the former and the Virginia of the latter type the first made the better growth at the station. In this climate where there is no frost the soybean will mature more quickly in the winter or season of the shortest days than in the summer, but the height of the plant will be less and the yield of beans correspondingly so. In 6 weeks the plant begins to form pods and in 10 to 12 weeks to ripen seed, depending upon the variety. Interplanted with bunch beans the soybeans in 6 weeks were on the average as high again as the former.

Where a staple like the bean fills such an important place in the dietary of a people as it does in Porto Rico, the demand for some certain variety is naturally greater than for others and the price paid for it is correspondingly higher. With the introduction of another plant like the soybean, which makes higher yields and is better adapted to local conditions than the favorite bean variety, the people should be encouraged to acquire a liking for it. Usually, however, it is difficult to effect an immediate change in the taste or habits of any people; hence the work of generally introducing the soybean into the local dietary will probably be slow. The soybean can be prepared in many ways for the table, but to tempt the people of the island to try it the vegetable should be prepared in a way that will enable it to replace the bean as nearly as possible.

The garbanzo, or chickpea, is consumed in large amounts locally. It is cooked with other vegetables including potatoes and cabbage. By substituting soybeans for chickpeas in the mixture, the change in taste is less noticeable than when the soybean is cooked alone. The soybean when baked with pork with molasses added can be made to take the place of the beans commonly used in this dish.

That the soybean can be more easily and economically grown here than the ordinary bean and can be used as food in a greater variety of ways justifies further efforts to extend its use. Its freedom from insect and fungus attack and its ability to make large growth in a given time adds to the value of its introduction.

FLOWERS

An industry that might prove to be remunerative in Porto Rico is that of flower-seed growing. It is especially promising with flowers requiring hand labor for cultivating and harvesting. In the Tropics

seed can be produced during the winter months of the North for sowing the following spring. This fact makes it possible to furnish seed to the States during seasons of failure there. Realizing this, the station has for some years been trying to determine the possibility of growing some of the more popular annual flowers of the North. The following are the results:

Ageratum sp. Grows well both from seed and cuttings. Produces many flowers and seeds.

Arctotis sp. Makes good growth and blooms profusely. The daisies are desirable for use as cut flowers.

Aster. Flowers sparingly and is short-lived. Produces few seed.

Balsam. Of easy growth. Produces much seed.

Calendula sp. Grows rapidly, blooms profusely, and makes large yields of seed.

Candytuft. Grows well, flowers profusely, and produces an abundance of seed.

Cape-marigold (*Dimorphotheca* sp.). Produces good flowers and is worthy of further trial. The seed is weak.

Carnation. Grows well and produces viable seed.

Chrysanthemum. Grows slowly. The plants are weak and the flowers small. No seed is produced. Apparently the climate is too warm for vigorous development of the plant.

Clarkia sp. Makes fair growth and bears small flowers. Probably not cold enough here to induce seed production.

Cockscomb (*Celosia* sp.). Grows without trouble and produces abundant seed.

Coreopsis sp. Makes good growth, produces fine flowers, and develops seed.

Cornflower (*Centaurea* sp.). Produces many flowers, but the seed is poor and not worth saving.

Cosmos sp. Grows well and produces seed. Some varieties reseed themselves.

Cypress vine. Grows wild in Porto Rico. It flowers and bears seed abundantly.

Dahlia. Grows well, but the roots are attacked by rot.

Dutchmans-pipe (*Aristolochia sipho*). Makes rank growth and produces many seeds.

Everlasting or strawflower (*Helichrysum* sp.). Grows fairly well, flowers freely, and produces seed.

Flowering tobacco (*Nicotiana* sp.). Grows well, but the flowers are small, few, and of poor quality.

Forget-me-not (*Myosotis* sp.). Grows well but is attacked by a die-back that prevents seed production.

Gaillardia sp. Grows fairly well, producing large clusters of good-sized flowers and seeds.

Godetia sp. Makes poor growth and is a failure for seed production.

Hollyhock. Grows well, flowers, and produces an abundance of seed.

Kochia sp. Makes good growth during the dry season and produces seed. Wet weather is fatal to the plant.

Kudzu. A failure. The vines do not develop.

Laceflower (*Trachymene caerulea*). Flowers well but does not produce seed.

Larkspur. Plants vary greatly in growth; some are good, whereas others are weak. Produces few blooms and seeds.

Lupine. Does not make satisfactory growth or produce seed. Further trial is advisable, inoculating the soil with the proper nodule-forming bacteria.

Mentzelia sp. Makes poor growth. The flowers are few and do not develop.

Mignonette. Grows and flowers well, but is attacked by a disease that prevents seed production.

Morning-glory. Grows quickly and produces many flowers, but seeds sparingly.

Nasturtium. Grows well and blooms freely, but the yield of seed is very variable, depending on the soil and the rainfall. Not recommended as a seed crop until tested further.

Nemesia sp. Grows fairly well, but produces no seed.

Pansy. Makes slow growth. The flowers are few, and the plant produces no seed.

Petunia. Grows luxuriantly and produces many flowers. The seed is weak and valueless.

Phlox. Makes excellent growth, blooms, and produces viable seed.

Silene sp. Produces a fair amount of bloom, but no seeds.

Snapdragon (*Antirrhinum* sp.). Started in boxes and transplanted. The small plants, while delicate, flower profusely and give an abundance of seed.

Stock. Grows slowly and produces fine bunches of flowers but forms no seed.

Sunflower. Grows well at all seasons. The seed heads are better filled when the soil is not too rich. The plants make their tallest growth in summer, apparently being affected by the length of day.

Sweet pea. All kinds grow rankly here, but only the early or winter-flowering varieties bloom and bear seed abundantly. (Fig. 6.) The latter kind developed from a tropical pea is well worth growing for its flowers and seed. When peas are planted for the first time the soil must be inoculated with the proper nitrogen-fixing bacteria. With later plantings this is not necessary.

Treemallow (*Lavatera* sp.). Produces fair-sized flowers but no seed.

Velvetbean. Makes rank growth, flowers, and fruits.

Wallflower. Grows well and flowers, but produces no seed of value.

Zinnia sp. May be sown in the open. The plant is of easy growth, produces many flowers and seeds, and can be grown successively throughout the year.

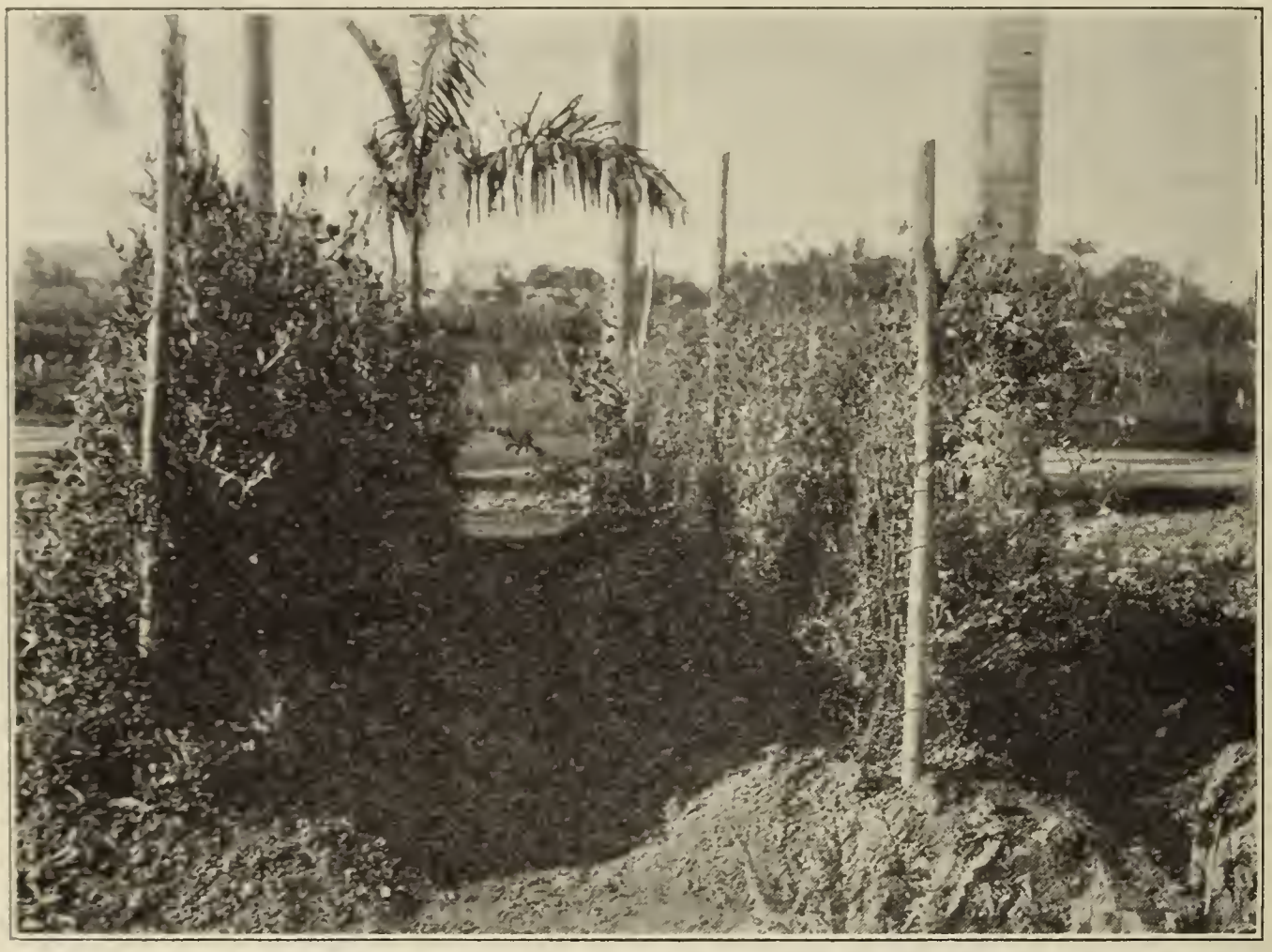

FIGURE 6.—Sweet peas. Left, summer flowering; right, winter flowering

Lends itself to breeding work, as the many types may be developed rapidly by successive plantings.

ROOTING CUTTINGS

Some plant cuttings strike root readily, others with difficulty, and still others not at all. In trials at the station of planting cuttings in beach sand, fine river gravel, charcoal, and potting soil, those grown in the gravel gave the best results. In trials of setting cuttings in sand over various organic substances, those holding moisture gave better results than did those given better drainage. The cuttings used were both herbaceous and hardwood and included tomatoes, sugarcane, cacao, coffee, *Petrea* sp., *Allamandra* sp., *Holmskioldia* sp., poinsettias, and bougainvilleas.

In trials with water solutions many chemicals in varying percentages were used. The most striking result was obtained with lime. A water-saturated solution made by using air-slaked lime in some

excess produced the greatest root formation. In some instances all parts of a given plant in limewater grew, whereas all parts in other solutions and water alone failed. Cuttings of sugarcane soaked in saturated lime solution for 10 days gave 100 per cent germination when they were planted in the field, whereas cuttings that were soaked in water gave only 20 per cent germination, and those in other solutions gave even less.

The fertilizer elements nitrogen, phosphorus, and potash in their various combinations hindered the rooting of cuttings.

Bottom heat, produced artificially or by the decay of organic matter, was favorable to the growth of cuttings in all instances, giving an increased germination of about 10 to 50 per cent.

Many trials were made of planting cuttings under artificial light of different colors, but the results obtained were inconsistent. Under normal light the cuttings were stockier and of better color. Some of the cuttings under colored light had longer shoots but these were spindling, weak, and blanched.

SHADE FOR CITRUS

Growing coffee in the shade of leguminous trees has long been successfully practiced in Porto Rico, a region lying well within the Torrid Zone. Many observations indicate the advisability of growing citrus also under at least partial shade. Leguminous trees would enrich the soil wherein the citrus is growing and could be thinned or removed without injuring the citrus trees. Low-growing leguminous trees are recommended for interplanting with citrus because they will not overtop or damage the trees when blown over by storm. The dwarf bucare (*Erythrina corallodendron*) and the gliricidia (*Gliricidia sepium*) are especially recommended for the purpose. It has been observed that large numbers of orange trees in the wild state make good growth in shaded and sheltered valleys of the western districts of the island. These are seedling juicy oranges of good flavor and the trees are unusually scale-free considering the fact that they have never been sprayed. Beneficial fungi thrive in these moist places and hold the scale in check. Grapefruit when grown at the station in the shade has a better flavor than that grown in the sun, and the skin is smoother. On the other hand, the color is lighter and apparently the fruit ripens later in the season. The trees grow faster but bear fewer branches than do the trees grown in the sun.

REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

MANAGEMENT OF CANE SOILS

Results of experiments on the decomposition of cane tops and trash when incorporated in the soil, as reported in 1928, showed the rate to be greatly accelerated upon the addition of lime to the soil. This difference in rate of decomposition was shown by comparing the daily amounts of carbon dioxide produced by the different treatments with the weekly determinations of the nitrates formed.

These experiments were continued during the year to determine the effect on the rate of decomposition of cane tops and trash and nitrification of their nitrogen content with increased additions of lime.

Decomposition was carried on at normal temperatures, 200 grams of soil to 3 grams of a mixture of air-dried tops and trash being used for the purpose. This ratio was adopted because it is close to that of the average tonnage of dry tops and trash ordinarily produced per acre to the weight of an acre layer of soil 7 inches deep. The plant residue was applied in two ways, (1) mixed thoroughly with the soil, and (2) left on top as a mulch. The applications of lime were equivalent to 0, 1, 2, and 3 times the amount shown by analysis to be required for neutralization. Water was added up to 90 per cent of the soil's maximum water-holding capacity and then allowed to evaporate until the soil's optimum had been reached. The soil was maintained at this point during the rest of the trial. Two weeks were required to bring the moisture content down to optimum, when the first analyses for nitrate nitrogen were made. To obtain further information on decomposition and nitrification, a similar trial was made, but enough ammonium sulphate was added at the start to supply nitrogen at the rate of 2½ per cent of the dry weight of trash and straw used. Further comparative tests were made by replacing the tops and trash with an equal amount of air-dried soybean straw and stems. The material used was taken from full-grown plants the seed pods of which had barely formed. This material was mixed with the soil, and twice as much lime was applied as was required by the soil. Carbon dioxide determinations were not made, and only weekly nitrate nitrogen and occasionally ammonia nitrogen determinations were made.

The first analysis was made 15 days after the experiment was started and analyses were then made at weekly intervals. Soils with or without lime treatment showed a small gradual increase in the nitrate-nitrogen content with only an occasional drop. Soils receiving lime made a small but definite gain and there was a tendency toward slightly larger increases in favor of soils receiving two and three times the lime requirement. Soils receiving nitrogen in addition made considerable gains weekly in nitrate-nitrogen content. The amounts were from three to five times that of the no-nitrogen soils, those receiving lime in addition always showing to advantage. Increases in lime added were followed in the first three-fourths of the experiment by a higher nitrification rate. However, soils receiving only lime and plant material showed no gain. Bare traces of nitrates were always present, amounting to less than 2 parts per million. The nitrate content rose only on one occasion and then from 2.5 to 4.5 parts per million. The nitrate content of soils receiving lime, plant material, and nitrogen in addition was considerable although in many cases well below the quantity contained by soils receiving lime and ammonium sulphate. However, though this difference amounted to 100 parts per million nitrogen in favor of the no-straw soils during the first half of the experiment, the gains in nitrate nitrogen during the second half were enough to cause this difference to decrease considerably. Again increased addition of lime produced differences in their favor. However, this effect was not constant.

Soils having lime and plant material as a mulch contained more than traces of nitrates at all times. The nitrate content, however, amounted to only from one-fourth to one-fifth of that in soils receiving no treatment or only lime. After the third week it decreased from one-eighth to one-eleventh. It was only in the last three weeks that they

showed again a small upward trend or slight gain. Small gains were also produced by the use of increased quantities of lime.

Soils receiving nitrogen in addition to plant material as mulch contained nitrates in considerable quantities. The nitrate content was considerably above that in soils having straw mixed with soil and only slightly below that in soils having no straw but receiving the lime and nitrogen addition. Again a steady gain was produced by the use of lime and further gains by its use in increased quantity.

The greatest decomposition and nitrification were shown by soybean straw and stems. The first analysis, made 15 days after the test was started, showed 135 parts per million nitrogen as nitrate or nearly three times the amount present in soils receiving lime alone as treatment. The soils gained gradually every week and soon their content was the same as for soils which were mixed with straw and in addition received nitrogen. The highest nitrate content determined was 233.4 parts per million nitrogen.

No attempts were made to determine ammonia or nitrite nitrogen under the conditions of the experiment outlined, the amount of carbon dioxide evolved, or the acidity of the soil. The results are in conflict with those obtained in a previous experiment. In the present experiment twice the amount of soil and straw used in the first experiment was employed, but the soil and the plant material used in both instances and the ratio of soil to plant material were the same. However, the previous experiment was made during July, August, and September, while this one was performed during November, December, and January, and the temperature was markedly different. The soil appeared to be more closely packed and the action slower than in the previous experiment, judging from the formation of nitrates when plant material was added to the soil. Soils which had been mixed with plant material alone or with lime in addition contained from 2.5 to 4.5 parts per million nitrate nitrogen at the end of the experiment, or in the thirteenth week, whereas in the previous experiment nitrates appeared early in the fifth week when lime was also applied.

The action when the plant material was added as mulch was not so slow as when mixed with the soil, since nitrates were present every week. The amounts present were, however, smaller than in the case where only one-half the amount of plant material and soil was employed. However, the soybean plant material added under the same conditions underwent considerable decomposition, judging from the amounts of nitrates formed weekly.

Notwithstanding these discrepancies, increased additions of lime were followed by increased formation of nitrates, especially when nitrogen also was used. However, this difference, though steady throughout part of the experiment, was never as great as that between the no-lime and the lowest amount of lime used. These differences had a tendency to grow smaller after the ninth week of the experiment.

CANE-SIRUP MANUFACTURE

Attempts were made to obtain a light-colored cane sirup of high grade having the full, peculiar, agreeable flavor. A modified form of the methods recommended by the Bureau of Chemistry and Soils of the United States Department of Agriculture was employed, and the products thus obtained were compared in flavor, color, and clarity. The

juice was clarified easily by the use of phosphoric acid and lime, but considerable sediment formed later. The use of even a very small quantity of lime had a tendency to produce a darker final product. To avoid this, attempts were made to restore the cane juice to the original acidity or slightly higher after clarification with phosphoric acid and lime. The product obtained was of better color and taste than that clarified in the same manner but with acidity unchanged after clarification.

ANALYTICAL WORK

Soils, guanos, drinking waters, and other materials sent in from various sources were analyzed whenever it was thought the results would be of general interest or importance. Analytical work was done also for the other departments of the station and for use in the projects outlined.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

HURRICANE DAMAGE TO MISCELLANEOUS PLANTINGS

The hurricane of September 13, 1928, seriously damaged or definitely terminated several long-term experiments of the horticultural department. Subsequent rehabilitation work at the station and with the planters consumed much of the horticulturist's time. After the storm little more than one-third of the coconut palms remained standing in each experimental group. The cacao plantings in greater part were rendered almost valueless, many of the trees not having recovered at the time of the hurricane from the ill effects of the much milder hurricane two years earlier. Avocado trees were demolished. As a result of the hurricane and unfavorable soil conditions, less than one in four of numerous avocado trees set in 1926 remained alive at the end of the present year. Among the totally demolished trees was one which had been worked over to the Fuerte variety in the spring of 1924 when already a large tree. In August, 1928, its spread was estimated to be 30 feet, its height to be 43 feet, and the crop to comprise between 350 and 400 well-developed fruits. A large branch of the Itzamna avocado at 3½ years from grafting was girdled by the storm to a width of about 9 inches. This girdled branch blossomed, and in June carried 49 fruits which were half developed or more. The mango orchards suffered severely, all the limbs being broken from many trees, and some trees being killed outright. A number of years will be required for the majority to regain their previous development. Many exotic trees of economic or ornamental value were badly damaged or totally destroyed, including an avenue of 15-year-old trees of *Swietenia candollei*. This species proved to be very susceptible to hurricane damage. More than half the trees were killed and the others were badly broken. The yam crop suffered to such an extent that of some varieties less than the amount of tubers planted was obtained on digging the mature crop.

COFFEE

The station coffee plantings were damaged in varying degrees, but not as much as were plantings in districts over which the storm cen-

ter passed. Some trees were badly broken, others were bent out of position, and still others were sapped of vitality. Some of the plantings will have to be replaced, and to this end nurseries have been established. The crop carried on the trees was very materially reduced, and many trees produced a very light crop or nothing whatever in the succeeding season.

The damage to the station plantings of Excelsa coffee was comparatively slight although some reduction in yield followed, the 1929 crop from the main planting being only three-fifths that of the average annual crop of the five years preceding.

The coffee in the Las Vegas fertilizer experiment fortunately was only slightly damaged by the hurricane, and the experiment is being continued without a significant interruption. No tree was wholly destroyed, and the highest destruction through breakage in any plat was placed at about 2½ per cent of the total growth in the plat. It was impossible to determine to what extent the crop was blown off, but from the appearance of the trees it is believed that the harvested crop, although reduced in amount, gave a fair indication of the relative production of the different plats. The lowest yield from any fertilized plat was twice as great as that from the check. Plat 4 led in production. It had formerly received nitrogen only and yielded less than any plat in the series; it had now had a semiannual application of a complete fertilizer, containing a high percentage of potash, for two years. Prior to the hurricane it was noted that this plat had changed from one of the poorest appearing of the plats under test to one of the best, being in good foliage and carrying a heavy crop.

The different species of trees used for shading coffee showed pronounced differences in ability to withstand the force of the hurricane. In the most severely damaged regions where the large trees of *Inga vera* were thrown over, broken, left barely alive, or killed outright, the *Erythrina berteroana* had developed new leaves within a few weeks after the storm, appeared to be in exuberant health, and furnished ample shade for coffee. For some years the station has recommended the planting of this tree for shading coffee. Its quick recovery after the storm demonstrated its value in such an exigency. *Gliricidia sepium* also showed decided wind resistance by the slight amount of injury received in contrast to the heavy damage in near-by Ingas.

The green scale (*Coccus viridis*), until comparatively recently unknown in Porto Rico, was observed to do serious damage to coffee, citrus, and other plants in several regions of the Island. One coffee planter reported that this insect has been present on his plantation for over six years. This was the earliest report received of its presence in Porto Rico. Conditions favorable to the development of scale insects, following the widespread destruction of shade in the coffee plantations, caused this new pest to increase rapidly and it was found to be widely distributed. Planters were advised to spray infested nurseries with the spores of parasitic fungi during the rainy season and to use contact insecticides during dry weather.

Timely articles containing suggestions to coffee planters were published locally, and seeds of both coffee and trees for shading coffee were distributed.

YAUTIAS, DASHEENS, TAROS, AND SWEETPOTATOES

In contrast to the yam crop, which of the root crops was the one most adversely affected by the hurricane, the yautias, dasheens, and taros yielded particularly well. The practice of planting in holes left to fill gradually under subsequent cultivation was again tested in contrast with plantings that were left level. The two planting systems were tested in alternating plats of 10 plants each, 16 plats being planted with yautias, and 10 with taros and dasheens. Greater yields followed the former treatment as was the case in the preceding year, the increase for the yautias being 28 per cent and for the dasheens and taros 4 per cent.

The individual "hills" in a 100-plant row of a single variety of dasheens receiving similar cultural treatment and growing in ordinarily uniform soil and yielding well, were weighed separately on digging. The grouping of these 100 hills for comparative purposes showed striking differences. If each 10 consecutive hills is considered as a group, the most productive group will be found to have outyielded the least productive by 55 per cent. The maximum difference between consecutive groups was 29 per cent. When 10 groups were formed by taking every tenth hill, the maximum difference between groups was 17 per cent. When instead of 10 hills each group consisted of 20 hills chosen consecutively, the difference between the highest and lowest yielding groups was 31 per cent, with a maximum difference of 22 per cent between consecutive groups. When groups of 20 hills were formed by the selection of every fifth hill, the maximum difference was 9 per cent. When alternate plats of 10 consecutive hills were each grouped into two larger plats of 20 hills each, the difference between them was 10 per cent. When the row was divided midway into two groups of 50 hills each, the difference was 4 per cent. When alternate hills were taken to form two groups of 50 hills each, the difference between them was 3 per cent.

Extensive distributions of taros, dasheens, and sweetpotato slips were made to planters.

BEANS

In March a planting of beans was made for the purpose of comparing the production of snap beans of 8 pole and 16 bush varieties, or differently named strains, of the Temperate Zone, and 12 varieties of the Tropics. The rows were 50 feet long and the standard row was reduced to 100 plants of the pole varieties, or 150 plants of bush varieties. Various uncontrollable factors resulted in some variation from the standard. Two or more widely separated rows were planted with each variety, two varieties excepted. Every fifth row was planted with the Porto Rican Red (Guayamera type) as a check, this variety, despite its toughness and fiber, being extensively used locally as a snap bean. For rows adjacent to the Porto Rican Red, the single row of the latter served as the check. For rows not adjacent to it, the average of the nearest Porto Rican Red rows on either side was taken as the check.

All pods of edible size were picked at weekly intervals at 6 to 12 weeks after planting, and comparisons were based on the crop picked within this period. While this period covered the production of the bush varieties very satisfactorily, the pole varieties continued to produce pods for a somewhat longer time, and thus suffered in com-

parison. White grubs were very numerous in that part of the field which was planted with the pole varieties and either killed or weakened most of these plants, as was reflected in the pronounced differences in growth and production of the check rows. Pods were counted and weighed, and the rows were compared as to production per plant and per row. The result was also expressed in percentage of the check. The data on the two or more rows of each variety were then averaged for variety comparisons.

COMPARISON IN REGARD TO NUMBER OF PODS

Tropical varieties.—The production of the 23 check rows of Porto Rican Red beans ranged from 354 to 3,298 pods per row, and averaged 1,980 pods. Venezuelan Black led all the varieties with an average production of 5,678 pods, and was followed by Porto Rican White with 5,098 pods, each row of each variety producing more than 100 pods per linear foot of row. Three other tropical varieties produced more than the best check in each of two rows. Expressed in percentage of the check, the production of pods per row was 278 for Venezuelan Black, 206 for Santo Domingan Cinnamon, and 203 for the Porto Rican White.

The average number of pods produced per plant ranged for the check rows from 2.8 to 22 pods, the row average being 13.6 pods per plant. The highest yielding check was surpassed by both rows of five other tropical varieties, Venezuelan Black leading with an average production of 38 pods per plant, and the Porto Rican White coming second with 34 pods per plant. Venezuelan Black led also in a comparison of varieties with the respective checks as to pods produced per plant.

Temperate Zone varieties.—A single row only, Extra Early Valentine, exceeded the best check in number of pods produced per row. This variety gave also the highest average production, 2,595 pods per row. It was followed in sequence by Canadian Wonder, Currie Rust-Proof Black Wax, and White Creaseback. The average pod production per row of leading varieties expressed in percentage of the check was 275 for White Creaseback, 119 for Burger Stringless Green Pod, 111 for Burpee Stringless Green Pod, 110 for Canadian Wonder, 108 for Extra Early Valentine, 106 for Earliest Red Valentine, 104 for Kentucky Wonder, and 104 for Refugee.

Compared in regard to pods per plant the best check was outyielded by both rows of one variety only—White Creaseback—a pole bean, which gave an average yield of 24.7 pods per plant. Extra Early Valentine led the bush varieties with a production of 19.7 pods per plant, and was followed by Full Measure, 18.3 pods, Canadian Wonder, 17.6, Currie Rust-Proof Black Wax, 17.4, Fordhook Favorite, 16.9, Hodson Wax, 16, and Round Yellow Six Weeks, 16 pods per plant. In comparison with their respective checks, the pole varieties were led by White Creaseback, and the bush varieties by Round Yellow Six Weeks, followed by Earliest Red Valentine and Extra Early Valentine.

COMPARISON IN REGARD TO WEIGHT OF PODS

Tropical varieties.—The Porto Rican Red bean ranged in production per row from 1.8 to 28 pounds, averaging for the 23 rows 15.7 pounds. The Porto Rican White bean led all the varieties with a production of

34.8 pounds per row. This was the only variety of which both rows outyielded the best check. The Venezuelan Black bean came second with 28.8 pounds per row. As compared with their respective checks, the Venezuelan Black led, producing 184 per cent, and the Porto Rican White ranked second, producing 168 per cent as much as the check. Three other varieties also ranked well above their checks.

The average weight of pods per plant produced by the Porto Rican Red bean was 1.7 ounces. The most productive row of the check averaged 3 ounces per plant. The Porto Rican White led all the varieties with a production of 3.7 ounces per plant. The Venezuelan Black and Brazilian Buff were the only other tropical varieties which averaged 3 ounces or more per plant. Five other varieties produced more than 2 ounces per plant. Tropical varieties outyielding the check by 50 per cent or more, named in descending rank, were Venezuelan Black, Porto Rican White, Santo Domingan Cinnamon, and Cuban Red.

Temperate Zone varieties.—Fordhook Favorite leading the northern varieties with a production of 25.2 pounds per row, ranked third of all the varieties, including the tropical. In sequence, Hodson Wax and Burpee Stringless Green Pod produced 23 pounds or more; Mohawk, Currie Rust Proof Black Wax, and Canadian Wonder over 22 pounds, Full Measure, White Creaseback, and Burpee Brittle Wax, 20 pounds or more; and Extra Early Valentine, 17.5 pounds per row. The production of the higher ranking pole varieties, expressed in percentage of the checks was 416 for White Creaseback, 232 for Kentucky Wonder, 217 for Burger Stringless Green Pod, 173 for McCaslan, and 133 for Kentucky Wonder Wax. For the bush varieties, the percentages were 140 for Burpee Stringless Green Pod, 121 for Canadian Wonder, 105 for Fordhook Favorite, 101 for Hodson Wax, and 101 for Currie Rust Proof Black Wax. Others which came within 10 per cent of yielding as much as their checks were, in descending sequence, Round Yellow Six Weeks, Mohawk, Extra Early Valentine, Refugee, and Full Measure.

Only one pole variety, White Creaseback, and one bush variety, Fordhook Favorite, produced more than 3 ounces of pods per plant. Nine other varieties, Full Measure, Currie Rust Black Wax, Mohawk, Hodson Wax, Burpee Stringless Green Pod, Canadian Wonder, Burpee Brittle Wax, Extra Early Valentine, and Bountiful, named in order of diminishing production, produced 2 ounces or more per plant. The production per plant of the pole varieties, expressed in percentage of the check, was 580 for White Creaseback, 345 for Kentucky Wonder, 322 for Burger Stringless Green Pod, 250 for McCaslan, 213 for Kentucky Wonder Wax, and 153 for Horticultural; and of the bush varieties, 139 for Burpee Stringless Green Pod, 126 for Canadian Wonder, and 120 for Fordhook Favorite. Others outyielding the check by less than 20 per cent were, named in descending rank, Full Measure, Round Yellow Six Weeks, Earliest Red Valentine, Bountiful, Extra Early Valentine, and Hodson Wax.

The tropical varieties of beans are characterized by pods which become tough and stringy very soon. For use as snap beans they must be picked while they are very immature. A common local practice is to trim the pods along either suture, thus removing a considerable amount of pod as well as string. These trimmed pods command a higher price. Notwithstanding their inferior quality,

the local snap beans find a ready market. For quantity production, irrespective of quality, Porto Rican White and Venezuelan Black led all the varieties tested.

As has just been shown, numerous improved Temperate Zone varieties of garden beans, producing brittle and some varieties producing practically stringless pods of high quality, do well locally. Temperate Zone varieties which were shown to be of outstanding merit among the bush sorts were Fordhook Favorite, Burpee Stringless Green Pod, and Full Measure. These were productive, bearing round pods 6 inches long which were brittle, stringless, and of excellent table quality. Hodson Wax was the most productive wax variety. The pods attained a length of 6 to 6½ inches. They were flat, stringy, and brittle when young, but became tougher as maturity approached. Among the pole varieties, White Creaseback, the most productive, developed pods 4 to 5 inches long. These pods were rounded somewhat like a pea pod, brittle, only slightly stringy, and of fair table quality. Kentucky Wonder produced pods 8 inches or more in length. These became round or fleshy as maturity approached, brittle, and slightly stringy, but were of excellent table quality.

REPORT OF THE PLANT BREEDER

By R. L. Davis

SUGARCANE

SEED VIABILITY EXPERIMENT

The sugarcane seed viability experiments as reported in 1928 indicated that inadequate rainfall is responsible for the low germinations secured from arrows collected near Mayaguez. That this is true was shown by the results obtained on the Las Mesas breeding plats, which are located about 3 kilometers from Mayaguez at an altitude of 1,000 feet. Rainfall there was abnormally high during November and December, 1928, and in addition to it, irrigation water was applied by hand to the breeding plats whenever more than four days of dry weather occurred. An average germination of 43 seedlings per arrow was secured from 49 arrows of P. O. J. 2364. This is the first time on record that very viable sugarcane seed has been secured at Mayaguez. As a result of this production, it is thought that one of the greatest handicaps to cane breeding at Mayaguez has been overcome. With the production of viable seed in this district breeding work can be centered at the experiment station under careful supervision for the prevention of contamination of crosses by stray pollen.

BREEDING

New seedlings include 2,500 crosses between P. O. J. 2364 and Mayaguez 9, and self-pollinated seedlings of Mayaguez 9 (200), F. C. 1017 (1,100), Mayaguez 28 (100), Co. 281 (50), and P. O. J. 2725×B. H. 10/12 (7).

The seedlings of F. C. 1017 were discarded because of their inferior growth. Those of Mayaguez 9, Mayaguez 28, and Co. 281 afford some interesting material for genetics. As is shown in Figure 7, selfs of Mayaguez 9 grow erect, and stool moderately well, in contrast with those of Mayaguez 28 which have a spreading growth habit and

are prolific stoolers. Both of the progenies contained a good proportion of medium-sized canes, whereas all selfed seedlings of Co. 281 are thin-caned. Co. 281 is attractive as breeding stock because it is very high in sucrose and the seedlings grow erect, stool well, and shed their leaves freely. The marked susceptibility of these seedlings to mosaic is, however, a serious drawback.

The seedlings of P. O. J. 2725 pollinated with B. H. 10/12 were grown from arrows supplied by the Fajardo Sugar Co. They were too few to afford material for selection, but are interesting since they bear a striking resemblance to the male parent, B. H. 10/12. Some of these seedlings are very susceptible to mosaic, and on the maternal

FIGURE 7.—Contrasting growth habit of inbred sugarcane seedlings from Javan and Barbadian sources: A.—Self-pollinated seedlings of Mayaguez 9. These are second-generation inbreds from S.C. 12/4 and make erect growth at this age (2½ months). B.—Seedlings of Mayaguez 28 inbred the first generation. They are very prolific and spread out almost flat at this age. Mayaguez 28 is a seedling of P. O. J. 2725×S. C. 12/4 and contains one-eighth part Kassoer "blood"

side are probably chiefly derived from E. K. 28 stock. Others are highly resistant to the disease and are thus similar to Kassoer, one of the other maternal varieties.

The most promising progeny this year are seedlings of P. O. J. 2364 and Mayaguez 9. To determine whether these seedlings were all selfs or contained hybrids, germination counts were taken from arrows of P. O. J. 2364 tied to those of Mayaguez 9, and from arrows of the same variety collected from stools where the parent varieties were 12 to 15 feet apart. The germination for the arrows in contact with Mayaguez 9 was double that of the parent arrows which were separated from one another. Since Mayaguez 9 is pollen-fertile and the viability increased as the distance of separation was reduced, there was reason to believe that many of the seedlings were hybrids. The subsequent growth tends to confirm this prediction. Many characteristics of the male parent cane are to be found, such as late

arrowing habit, red canes of good girth and swollen joints, very healthy dark green leaves that shed freely, and ability to resist top rot. Many of these seedlings compare favorably with P. O. J. 2878 in stooling habit. This progeny is considered more promising for the West Indies than are crosses with P. O. J. 2725 or P. O. J. 2878, since the latter two varieties contain a large proportion of E. K. 28 "blood" which carries with it susceptibility to root disease and poor ratooning power.

THIRD AND FOURTH YEAR SELECTIONS

Of the 3 and 4 year selections from hybrids between P. O. J. 2725 and S. C. 12/4 or B. H. 10/12, the medium to late arrowing types failing to develop mosaic during three to four seasons when they were grown between infected stools, included Mayaguez Nos. 3, 7, 42, 48, 62, and 77. Of these, Mayaguez 7 and Mayaguez 48 arrow fully 4 to 6 weeks later than P. O. J. 2725. Additional study of "long crop" or "gran cultura" plantings of Nos. 3, 42, 62, and 77 is needed before more can be said definitely than that they will be very late in arrowing, if they arrow at all.

Measurements made in small plats of sugarcane at Hormigueros, grown in cooperation with Russell & Co., and in duplicate plats at Guayanilla, grown in cooperation with Central Rufina, showed at 4½ months a superiority of 6 inches or over in average height for Mayaguez Nos. 42, 47, and 45, in comparison with B. H. 10/12 grown in adjoining rows. In stooling habit there was a marked superiority over B. H. 10/12 for most of the Mayaguez seedlings. Mayaguez Nos. 44, 42, and 47, with 15 to 18 shoots per stool, were intermediate between the parent varieties, whereas Mayaguez Nos. 40, 28, and 49 were superior to P. O. J. 2725 in this character.

Hand-mill analyses indicate that Mayaguez Nos. 3, 62, and 77 are equal to and that Nos. 28, 44, 42, and 52 are superior to P. O. J. 2725 in sucrose content. Cooperative tests have been arranged to determine the milling qualities and yields of the more promising of these canes.

SWEET CORN

Selections from Mayaguez 1 inbred lines were again made for tender kernels. Adverse weather conditions at the time of planting so depleted the stand and stunted growth in the breeding plat that the data on this season's work were not dependable. Results of germination tests indicate that certain of the crosses between inbred lines of sweet corn are superior in vigor to Mayaguez 1.

FIELD CORN

The principal objective of the year's work with field corn was to continue a large number of the selfed lines that had been all but lost in the hurricane of September, 1928. Determinations of the percentages of soft starch in the kernels of a number of hybrids indicate that yield in Porto Rico is not correlated with high content of soft starch. The highest yielding hybrids were as a rule neither flinty nor very starchy, but intermediate in type.

Large numbers of vigorous selfed lines have been isolated from Castillear–1, the most promising source. Castillear–1–5–2–4–5 and Castillear–1–5–1–4–4 were especially outstanding, since most of the selfed lines from other parent ears were decidedly inferior in plant

growth and grain production. This is true even when lines inbred only two or three generations are compared with these Castillear–1 lines which have been inbred for four generations. Castillear–1–5–2–4–5 yielded a fifth generation progeny with most of the ears equaling or exceeding a length of 18 centimeters and a diameter of 4.4 centimeters. This size of ear approaches that of normal open-pollinated corn. Most of the ears were crease-dent in type, but considerable variability occurred in kernel color, from orange to red, row number, from 10 to 16, and in kernel shape, from round or lopped-shouldered keystone to keystone. Another Castillear line, No. 1–5–2–11, was almost equally promising in yield and, in addition, had shanks 6 to 7 inches long in the fourth-generation progeny. Long shanks are considered desirable, as a drooping-ear type could probably be bred from a combination of lines having this character. Drooping ears shed the heavy rains and consequently would avoid much of the ear rot that markedly reduces the yield in Porto Rico.

The chief point of emphasis in the corn-breeding work in Porto Rico is that of developing lines that are fairly high yielding so that when seed of hybrids is distributed the reduction in yield after the first crop will not be too great, and the interpollinations occurring in the field will give seed corn of fairly good quality.

REPORT OF THE AGRICULTURIST

By H. C. Henricksen

CITRUS INVESTIGATIONS

An intensive survey of representative citrus plantations in all the different citrus-growing districts was completed. The results of the work were submitted for publication.[1]

ROOT DEVELOPMENT

As the result of the plantation survey, some questions arose in regard to the differences observed in root development of different stock when grown in different soils and under different cultural treatments. Cooperative field experiments were started to determine the causes of these differences. Supplementary to making field experiments, small trees were planted in 30-gallon iron tanks. Fifty such plantings are now under observation.

CONTROL OF TIME OF BLOOMING

The financial success of the citrus industry in Porto Rico depends primarily upon the price obtained for the fruit. Since the price is governed by supply and demand, the control of time of blooming is probably the most important problem of the industry at present. A study of this problem was begun during the year. Four representative soil types were chosen for the purpose, each being divided into four plats. On each plat 4 trees, or 16 trees in all, were staked out. Samples of the soil from these plats and samples of the leaves, the buds, and the twigs are gathered periodically for analysis.

[1] Henricksen, H. C. citrus culture in porto rico. Porto Rico Agr. Expt. Sta. Bul. 33, 33 p., illus. 1930.

COLORABILITY OF GRAPEFRUIT

Several attempts have been made during the past few years to determine the differences in colorability of grapefruit, the causes of these differences, and the differences in efficiency of coloring rooms. The investigation was continued during the year, the methods used being based upon experience formerly gained. The results have been published for general distribution [2] and have already been of great assistance to fruit growers in the standardization of coloring methods.

PINEAPPLE INVESTIGATIONS

Practically all the agriculturist's time was devoted to citrus. However, he managed also to keep in touch with the pineapple problems and to continue noting the results of work started previously. Several varieties were interplanted in 1928 for the purpose of cross-pollination. Pollinating could not be done by hand as was originally planned, but some natural cross-pollination took place with the result that seeded fruits have been and are being produced. The seeds from these fruits were planted and have yielded several dozen seedlings. Selection of slips and transference of them from one soil type to another and from one altitude to another continue to be made in cooperation with growers. So far, however, the results have been indefinite. The control of time of blooming is of no less importance to the pineapple grower than it is to the citrus grower. Cooperative work along various lines was started for the purpose of determining what factors control blooming of the pineapple plant.

FRUIT GROWERS' ORGANIZATION

Assistance was again given in maintaining and increasing an interest in cooperation. A fruit growers' credit association was organized after the hurricane in 1928 and functioned successfully during the year. In conjunction with this association a fruit growers' improvement committee accomplished much important work. The agriculturist of the station was commissioned to go to Florida in August at the expense of the growers to study coloring methods and refrigeration. Refrigeration on steamers and precooling on the wharf are among the subjects that have been discussed for a number of years. As a result of the united effort of the growers and a steamship company, a modern precooling plant is now being erected on the wharf in San Juan and will be ready for operation by February 1, 1930. One of the important factors in organization work is the fruit growers' meetings which are held either in San Juan or some representative plantation. Nine town meetings and one field meeting were held during the year. The agriculturist acted as secretary of the meetings and prepared a report on each for distribution among growers whom it would be difficult to reach in any other way. A report upon observations made in Florida was also sent to all local fruit growers, and a report upon results of a refrigerating experiment conducted on the steamer by the agriculturist while en route to New York, together with notes on factors governing the selling of citrus fruits and pineapples in the States, was submitted to the improvement committee.

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[2] A mimeographed number of Agricultural Notes, available copies of which may be had upon application to the director of the station.

REPORT OF THE PLANT PATHOLOGIST

By M. C. Tucker

POKKAH BOENG AND CHLOROTIC BLOTCH OF SUGARCANE

Investigations on the pokkah-boeng disease of sugarcane were continued. Fusaria, isolated from diseased canes in Java, Porto Rico, and in Cuba, and grown in a series of parallel cultures, were compared with two authentic cultures of *F. moniliforme* isolated from corn roots in Missouri and from cotton roots in Georgia. The Java Fusarium was identified by Wollenweber as *F. moniliforme*, and the Cuban organism has been referred to as probably the same species. A comparison of the cane Fusaria with *F. moniliforme* did not confirm the identification. Moniliforme microconidia, considered to be characteristic of *F. moniliforme*, were repeatedly produced with the authentic cultures of that species, but never with the sugarcane isolations. The latter produced microconidia abundantly, but always in capitate clusters.

The cane Fusaria from the three regions showed considerable variation in growth and color production when they were plated in 2 per cent potato dextrose agar, oatmeal agar, steamed rice, and steamed potato plugs. However, the differences between strains from different regions hardly exhibited more marked variations than were observed between different strains originating in the same region. All the strains showed similarities in size and shape of macroconidia and microconidia, in type of microconidial fructification, and in absence of chlamydospores and sclerotia. All were considered to be strains, or, at most, varieties of a single species, which is not *F. moniliforme*.

As noted in the previous report,[3] the writer first noticed pokkah boeng in Porto Rico in 1927. Examination of the literature shows that Matz [4] observed a very similar disease in Porto Rico in 1922.

Consistent failure to isolate organisms from chlorotic blotches that showed no reddish or brownish spots or streaks and failure to produce such blotches by inoculation suggested that they are not the earliest symptom of Fusarium infection. Examination of many plantings of P. O. J. 2878 and of hybrids between P. O. J. 2725 and other varieties, especially S. C. 12/4, resulted in finding chlorotic blotch in every planting in which the canes were 3 feet high or more. At Fajardo the blotching was very common and conspicuous, but cases of discoloration from which Fusaria could be isolated were very rare. In a field of P. O. J. 2878 at Mayaguez about two-thirds of the leaves were blotched, usually near the base.

The chlorotic spots in which the discolored areas, typical of pokkah boeng, occur are yellowish whereas those without such markings are greenish white, and the chlorotic cells are mostly on the lower leaf surface, resulting in a conspicuous blotching on the under surface, and often a barely visible blotching on the upper surface. Hundreds of stalks producing the blotched leaves were split and examined for Fusarium infection in the central cylinder. The search was fruitless.

The evidence indicates that the chlorotic blotches are physiological in origin, and should be distinguished from pokkah boeng caused by

[3] Tucker, C. M. REPORT OF THE PLANT PATHOLOGIST. Porto Rico Agr. Exp. Sta. Rpt. 1928: 33. 1929.
[4] Matz, J. DRY TOP ROT OF SUGAR-CANE. A VASCULAR DISEASE. Jour. Dept. Agr. Porto Rico 6 (3): 25–47, illus. 1922.

Fusarium infection. The fact that pokkah boeng occurs most frequently on varieties which produce blotched leaves seems to be connected with increased susceptibility to fungus attacks in chlorophyll-lacking tissue. As the leaves emerge from the central cylinder, chlorotic tissues may, and occasionally do, spread downward into the spindle and involve succeeding leaves.

Results of experiments proved that the Fusaria isolated in Porto Rico, Cuba, and in Java are similar in pathogenicity on P. O. J. 2878. Inoculations of unwounded canes rarely resulted in leaf infection, and no cases of top rot resulted. Inoculations by injecting a suspension of spores and hyphae into the leaf spindle resulted in infection of the developing leaves and growing point. Injections into the growing point resulted in its death and top rot.

Isolations from top rot following stalk-borer attacks yielded Fusarium strains that were indistinguishable from those isolated from the leaf infections and suggest the presence of the fungus as a common saprophyte in cane fields.

Examination of the lengths and diameters of internodes subtending leaves with chlorotic blotch failed to show any correlation indicating a decrease in photosynthetic activity. The chlorotic areas do not split and cause the leaf to collapse as sometimes occurs with Fusarium infections.

The results indicated that the Fusarium is a weak parasite, scarcely able to invade and spread in normal green tissue, but that it is more virulent on chlorotic tissue; it can cause the death of the growing point and top rot when injected into the leaf spindle. Attempts to produce the disease by planting inoculated cuttings failed.

While the development of the disease in Porto Rico should be kept under observation, the experience gained by observation and experiment indicated that pokkah boeng is not likely to prove to be an important factor in the cultivation of P. O. J. and hybrid canes of Java parentage.

The nonparasitic chlorotic blotch seems to have no appreciable harmful effects on growth of cane.

PHYTOPHTHORA INVESTIGATIONS

The collection of strains and species in culture was augmented by the receipt of isolations from other investigators, and the studies on their morphology, physiology, and pathogenicity were continued.

Results of further experiments in inoculating avocado seedlings with *Phytophthora cinnamomi* confirmed those mentioned in the previous report. Soil inoculations resulted in a severe root disease and the death of the seedlings.

A new host of *P. palmivora* is the snapdragon (*Antirrhinum majus*). Plants at the College of Agriculture and Mechanic Arts, Mayaguez, wilted and died near flowering time. The roots were blackened and rotted. The basal part of the stems showed a browning and decay of the bark and the woody tissue was water soaked and darkened. *P. palmivora* was isolated but no inoculations were made.

REPORT OF THE PARASITOLOGIST

By H. L. Van Volkenberg

PARASITIC DISEASES OF CALVES

A study was made of the dairies in the vicinity of Mayaguez. Data were secured from fecal examinations, autopsies, and observations. It was found that only a very small percentage of the calves are raised to maturity and that failure to raise them is due principally to parasitic diseases. Replacements are usually made by purchase of adult animals from other districts more favorable for raising cattle, or by importation from the States. Successful dairying in Porto Rico requires the raising of normal, healthy female calves from the best cows in the herd, sired by a carefully selected bull.

In this district the returns from growing sugarcane on the better fields are usually higher than from cattle raising. The rainfall is heavy, the natural drainage in most places is poor, and the land receives the wash from an extensive mountain area. As a result, there is abundant moisture and it is very favorable to the development of several kinds of serious parasites infesting cattle, including lungworms, stomach worms, hookworms, and nodular worms. There are no frosts in this region and the worm eggs and nonresistant early stages therefore remain unchecked, except for their diminution in numbers during the dry season when they are less troublesome.

A special system of management and sanitation must be followed in raising young stock since pasture rotation is not economically practicable in Porto Rico. After an animal has reached its first year such a system is no longer necessary because resistance to infection has been attained and the tissues are not so susceptible to damage by the worms.

Very few calves are being raised by dairymen who believe that parasitic diseases are arrested by dipping or spraying the animals regularly for ticks, or by keeping the young stock on board or cement-floored pens.

Some young stock is successfully raised on farms in the mountains or in the dry southern part of the island where the parasites are restricted by the lack of moisture. A few dairymen, however, are very successful in raising young stock in connection with their dairies, indicating that the difficulties characteristic of this region may be overcome. Usually the owner who takes the proper precautions to combat parasites also gives more than average attention to proper feeding. The successful system followed at the station is that of keeping the calves in individual, well-drained, and well-ventilated pens for at least the first 6 months of age. The pens are cleansed daily of all droppings and litter. The cut grasses are fed from raised racks. Fresh drinking water, salt, and minerals are provided for the animals at all times. During the rainy season the calves under 1 year of age, and those older if necessary, are drenched regularly once each month with a solution of copper sulphate and nicotine sulphate. During the dry season they are drenched every six or eight weeks. Regular fecal examinations throughout the year keep a check on the amount and kind of infestation. The eggs of most of the parasites can be distinguished under the microscope. Regular treatment of the older calves on pasture gradually lowers the amount of infesta-

tion, indicating that the main source of reinfection is from the calves themselves and not from a few of the same kind of parasites that may be harbored by the adult animals. Dipping the cattle regularly about once a month has eliminated the external parasites, especially the ticks and lice. Further precautionary measures against attack are (1) to keep the manure from the calves separate from the other manure, and to spread it only on land to be plowed, as plowing buries the eggs and young worms and apparently destroys most of them; (2) to cut the grass fed to the young stock only from dry fields, or from well-drained parts of the same field; (3) to drench goats, both young and old, if they are kept with cattle, as well as the calves, because goats harbor several species of parasites that infest cattle; and (4) to consult a competent veterinarian in regard to the application of sanitary methods and especially concerning the administration of drugs.

LIVER FLUKES

The lesions caused by flukes in the livers of cattle have been observed to vary from those in goats. In cattle the liver lesions are similar to those described by pathologists. In goats the flukes without exception have been found usually in one or two cystic enlargements of the principal bile ducts. The cysts are filled with flukes and a dark liquid bile. The walls of the bile ducts, other than around these distensions, are not usually thickened and the cheesy masses of semisolid bile as well as the deposits of calcium salts in the walls have not been found. In cattle several hundred flukes may be found in one liver, whereas in goats rarely more than 15 or 20 are ever found. The flukes from goats are, on the average, larger than from cattle. The liver fluke yearly causes a great economic loss among cattle in Porto Rico. The parasites weaken the resistance of the animal to diseases, reduce the milk yield and breeding efficiency, render the meat unfit for food, and are often fatal to the animal.

At the station several drugs, including carbon tetrachloride and carbon trichloride (hexachlorethane), have been tried in the treatment of liver flukes in cattle. Some of the drugs have proved to be efficient after they were repeatedly used, but they can not be recommended for use at this time because of their toxic effect on the cattle. In time these difficulties may be overcome or a new specific discovered. Goats may be given carbon tetrachloride in doses of 1 cubic centimeter per adult animal with safety and with a high efficiency in removing the flukes.

Flukes in cattle may be controlled by preventive measures. To become infective the fluke must pass an intermediate stage in a snail. The snail requires either stagnant water, a sluggish stream, or a ditch in which to live and reproduce. For this reason pastures and grass fields should be properly drained to destroy the snail and eliminate the fluke. The snail is very sensitive to such chemicals as copper sulphate, salt, and lime, A dilution of 1 part copper sulphate to 1,000,000 parts water will kill it in a few hours under laboratory conditions. For Porto Rican conditions the spreading of lime on the wet pastures and grasslands is more practicable. Much of the soil is deficient in lime and it can be limed at low cost. Directions for the use of lime or copper sulphate for the purpose may be obtained at the station. Specimens of the snail transmitting the fluke will be furnished to those interested to aid in identification.

SWINE KIDNEY WORM

A check was made on the length of time required for the development of *Stephanurus dentatus*. A young pig was heavily infested with the larvae of this parasite grown in the laboratory. The ova were first identified in the urine during the twenty-eighth week. The pig was slaughtered a few days later. Many of the worms had reached the ureters, but apparently only a few were mature. Several of the intermediate forms had not yet started to migrate through the liver. Another pig of the same age used as a check was not infested.

It is rather generally believed here by farmers and others that the breeds of hogs introduced from the States are more susceptible to swine kidney worm than is the native pig. Usually North American hogs when slaughtered at the local abattoir show massive infestations. The probable explanation of this condition is that these more valuable hogs receive the greater attention, being kept in pens, and thus are exposed to a higher concentration of infection than is the native pig, which usually has free range.

TICK ERADICATION

One of the essential needs of the cattle industry in Porto Rico is the eradication of the cattle tick which transmits cattle fever. With the exception of tick fever, all the cattle diseases at present in Porto Rico can be controlled by individual effort. However, a systematic campaign to eradicate the tick should be conducted and financially supported by the Government. The eradication of the tick will enable livestock owners to raise cattle under more favorable conditions and with less likelihood of loss of the introduced animals than is now the case. Until the tick is eradicated, however, precautions should be taken to reduce the losses. During the last three years over 50 cases of tick fever have been observed affecting in most instances high-priced animals that had recently been imported from the States. In about one-half of these cases the cattle died. Probably 25 to 50 per cent of the adult cattle imported from the States die from the disease. Those that survive are cared for under expensive methods of management on the part of the owners. The safest method of importation is to bring in calves 2 to 9 months of age and give them very careful management. The young animals do not seem to be so susceptible to the acute form of the disease as are the older ones. The station has imported calves at different times and has not had a fatal case of tick fever among them.

It has been found that certain farmers who are raising improved stock including purebreds and crosses with native animals and who are dipping or spraying to control the tick are having several cases of tick fever each year with often a fatality. These farmers should use extra precautions by carefully dipping all the herd, including the work animals, more frequently than they do.

Animals introduced as adults usually suffer from an acute form of the disease and are likely to have repeated attacks. The prognosis is very unfavorable if the urine is blood colored or if the temperature remains rather constantly at 106° F. or above for more than three days. As soon as the disease is suspected the animal should be placed in a cool, shaded stall and carefully sprayed with a dip to remove every tick. A fever temperature is the most reliable means

of diagnosis until a blood sample can be taken and examined. Blanketing the animal with burlap that is kept soaked with cold water will also assist in lowering the body temperature. The reduction of the high temperature is very important and must be followed by good nursing, tonics, and restorative measures. The following remedial treatments have been recommended. Give quinine sulphate mixed with water as a drench in doses of 20 grams daily to each adult animal. The quinine should be given in divided doses and should be diminished in amount gradually each day after the first day. A more effective treatment is the injection by a competent veterinarian of quinine hydrochloride, or trypan blue, directly into the jugular vein of the sick animal. However, the constant injury to the health of all the cattle in Porto Rico by the tick, as well as the losses from the disease, may be ended by eradicating the tick. Tick eradication will be followed by an increase in the importation of dairy cattle from the States.

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